ISSN (e): **2250 – 3005** || *Volume, 07 || Issue, 12|| December – 2017 ||*
International Journal of Computational Engineering Research (IJCER)

Perfomance Analysis of Forced Convective V-Groove Solar Air Heater for Drying to mato Slices

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ABSTRACT
In this research the surface modified solar air heater hasbeen developed and experimentally investigated for dryingof tomato. The moisture content of the tomato has reducedfrominitialmoisturecontentof94.4%tothesafestmoisture content of about 15%. The time takenfor themoisture reduction of tomato to safest MC is 72 hrs ofdiscontinuous sunshine. To attain this moisture content theflowratehasbeenmaintainedat0.03kg/sduringthedrying process. This solar dryer enhanced the temperaturedue to the surface modified absorber plate. This dryer hasV-groovedabsorberplatewhichhasanangleof60^{o}andhastotalareaof1m^{2}.Thisexperimentachievedanefficiency of 25%.
Keywords:solardryer,V-Groovedabsorberplate,tomato,moisture content, efficiency.

I. INTRODUCTION

Increasing population is a grand challenge to balance betweenthe food production and food consumption. To overcome thefoodshortage,the foodsecurity neededtotransform somepracticesofstorage,foodproduction,distributionandconsumption. The improper drying leads to serous losses. Forsafe storage, drying plays an important role in food security.Different drying techniques are used for food storage such asdrying,dehydration,preservation,microwaveandfreezing,solardrying.Dryingplaysanimportantroleinglobal development.Thecommonproblemsfacedbydevelopingcountriesarepreservationofagriculturalproducts.Theimportantform offoodproduction is drying. Drying isanessentialprocessinunitoperationforfoodpreservationitremoves the moisture content and increases the shelf life of theproduct. Drying of agricultural products is a essential processto remove the initial moisture and make the products availablefor storage without any degradation. In most of the countriesthe food problems arise due to the insufficiency to preservefood surpluses rather than due to low production. In drying theenergy need is accomplished by either via renewable or nonrenewable energy sources. Solar drying is mostly used at thefarm level because it is low environmental impact, and lowcostfordrying foodproductsandagriculturalproducts.Inagricultural sector about 30% of world's energy is consumedamong that 3.62% of energy is utilized for drying. Based onmodeofoperationdryerscanbedividedintoactiveandpassive.The temperature is measured by using thermocouple atdifferentlocations.Amongthedifferenttypesofnaturalconvectionsolardryersthemixedmodesolardryerishigherin speedof drying.Thesolardryingisan best alternativemethodfor traditional drying.For a proper drying the evendistribution and flow uniformity of the turbulence intensityover the drying product are important for proper drying.In themixed mode solar dryer the drying temperature is maintainedin the range of 40-60°C and the ambient temperature is about15-30°C.The hot air temperature required for the safe drying is40-60°C.In shorter duration the removal of maximum moisturelevelwhichsavestheelectricalenergy.Forsafedryingof vegetables requires hot air in the temperature of 40-60^{o} C. Sothattheywillchoosethesolar dryer forenergysaving.

II. METHODS

MethodsofSolardryer

When there is food spoilage, there develops a foodshortage. To equalize the supply and chain there comes thedrying unit. Traditional dryers are tie consuming and has apossibilityofcontamination.Thecomparisonofsolardryingtodifferentdryingoptionsandshowsbenefitstoexistingdrying methods.Betterventilationhasagoodoutputofpreserved food products. The drying process in the traditionalway is taken ithee open field. To prevent these contaminationparticles solar dryer is best alternative source of drying. Theconstanttemperatureandairflowleadstotheconsistentdrying process with better quality. There are many developedsolar dryerssuchas

i.Direct dryingii.Indirect dryingiii.Mixedmodedrying

INDIRECTMODEOFCONVECTIVESOLARDRYER
In indirect type of solar dryer, the solar collector separatelyabsorbed heat energy and transferred to the drying chamber bynatural or forced convection. The indirect type solar dryer iscommonly usedtoincreasethe drying performance
andtopreservethequalityoffoodproductsduringthedryingprocess.Itsolarcollector,dryingchamber,andblowerassembly for airflow. This type of dryer increases the productqualitybymeansofclosedarea.

FORCEDMODEOF CONVECTIVESOALRDRYER
The forced mode of convection over the food through the useof fan. It requires a power source for the fans to provide the airflow it doesn't require an inclined for the air flow and thecollector placed horizontally with the fan at the one end anddrying bin at the other end. The forced convection dryer onsolar energy is less dependent as it provides an air flow itself.The continuous ventilation in forced convection solar dryerrequires a blower to force air through over the product. Thenatural convection dryers are time consumption unit, whereasthe forced convection dryers need electrical source for air inletand to maintain the air flow rate. It reduced the drying timehigher drying capacity and better quality of the product. Theforced air circulation is better than the natural air circulation ofrequireddryingconditionsanddoesnotrequireanyotherenergy.

SystemDescription
V-Groove
V-groove platewas used as an absorber.V-groove absorberhas a fined shape with large area of the absorbent.The mainadvantage of the system is that it has doubling the heat transferarea which also increases the heat transfer to the air. Doubleflow V-grooved absorber has 4-5% additional efficiency whencompared with single mode. The highest efficiency value ofV-groove double pass flow collector is due to large contactingarea of the V-groove absorber. In this type of absorber the airgetscontactwithbothsidesof theabsorber.

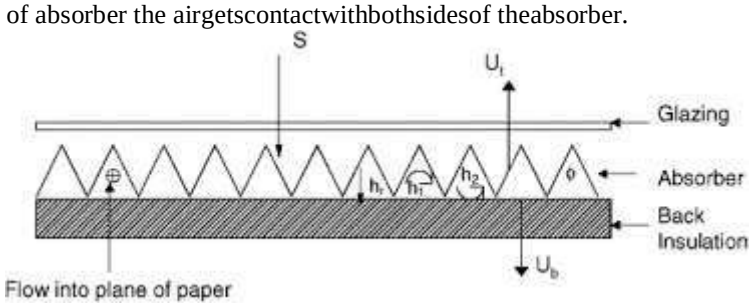

Fig.1V-Grooved absorberplate

THERMOCOL INSULATION
The standard thermocol sheet size thickness 39''x19'' is usedin the SAH to reduce the system loss. The sheets are packedand stacked together in a bundle or pocket.A closed cellstructure and support low thermal conductivity. It is used forthermalinsulationand itresist-5 to 500°Ctemperature.

GLASS COVER
Glass cover is used as the insulation material which helps tominimize theheat loss. The principalwork of the glass coveris glazing which helps to convert the short wavelength to longwavelength radiation, the more heat energy is absorbed in theplate and it reduced the heat loss. The thickness of the glasscover for the solar heateris0.5 mm.

III. EXPERIMENTATION STUDY

The experiment conducted for drying tomato slices.Tomatoes are quickly affected by microorganisms since it hashighest moisture content. To reduce that the indirect modesolar type forced convection dryer has been used in this study.The Tomato slices with a thickness of 2 mm and it placed inthe drying chamber.The solar air heater is designed with andimensionof1mlength,0.7mbreadthand0.5mwidth(1mx 0.7mx0.5 m). The glass cover is used as a top cover for sirheater.ThemainpartofthesolarairheaterisV-grooveabsorberplate.Thustheheattransfercoefficientisincreased
.ItincreasesthesurfaceareaofthesolarairheaterthusenhancestheReynoldsandNusslenumber.Thesolarairheater with maximum temperature is recorded during the highsunshine hours of 1:30 PM with the solar radiation range of890W/m^2.Thesunisabsorbedbytheabsorberplatefrom

thesolarradiation.Theradiationfromthesunhasshortwavelength. This long wavelength will converted into longwavelength once it reached the space between absorber plateand glass cover. The solar air heater receives airfrom theblower and which passes through the V-groove absorber plateand then the air gets heated and come out through the outlet.The solar air heater receives air from the blower and whichpasses through the V-groove absorber plate and then the airgets heated and come out through the outlet. The heated airpasses inside the drying chamber and dries the tomato samplewhichplacedinsidethe dryingchamber.

CALCULATION DESIGN:

Equilibriumcanbepresentedbythefollowingequation,

.M_W h_{fg}=m_a C_p (T_{OC}–T_{ic})Theheatenergyfromthecollector

Q=HR(**ατ)tAcηc**

The moisture removal equation,M_W=m_i (M_i–Mf)/(1-Mf)

Theefficiencyrelation,

ηc= Qu/HRAc

Th drying cabinet efficiency which includes powerconsumption,

E_d= P h_{fg}/ (HR A_C + W) tAirheater efficiency,

E=mc_p**T**/ IV

Themoisturecontentdeterminationfortheproduct$M= (W_s–W_d/W_s)$ x100

TIME	T_{in}	T_{out}	T_p	T_{DC}
10.00	32	48	46	44
10.30	35	53	50	52
11.00	33	58	62	57
11.30	34	60	67	59
12.00	33	61	69	60
12.30	34	62	70	61
1.00	35	63	72	62
1.30	34	62	73	61
2.00	33	60	70	59
2.30	32	59	68	57
3.00	33	55	64	54
3.30	33	53	60	52
4.00	30	48	55	46

Fig.2Tablevaluesofinlet,ouletandplatetemperatures ofSAH

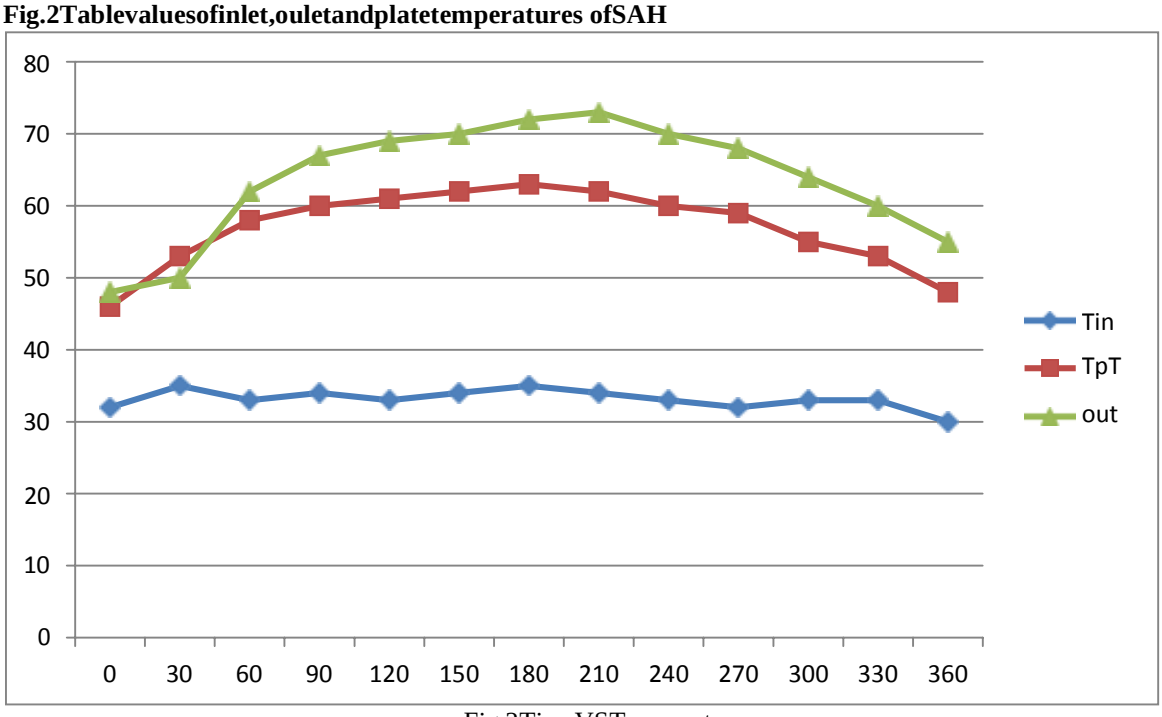

Fig.2TimeVSTemperature

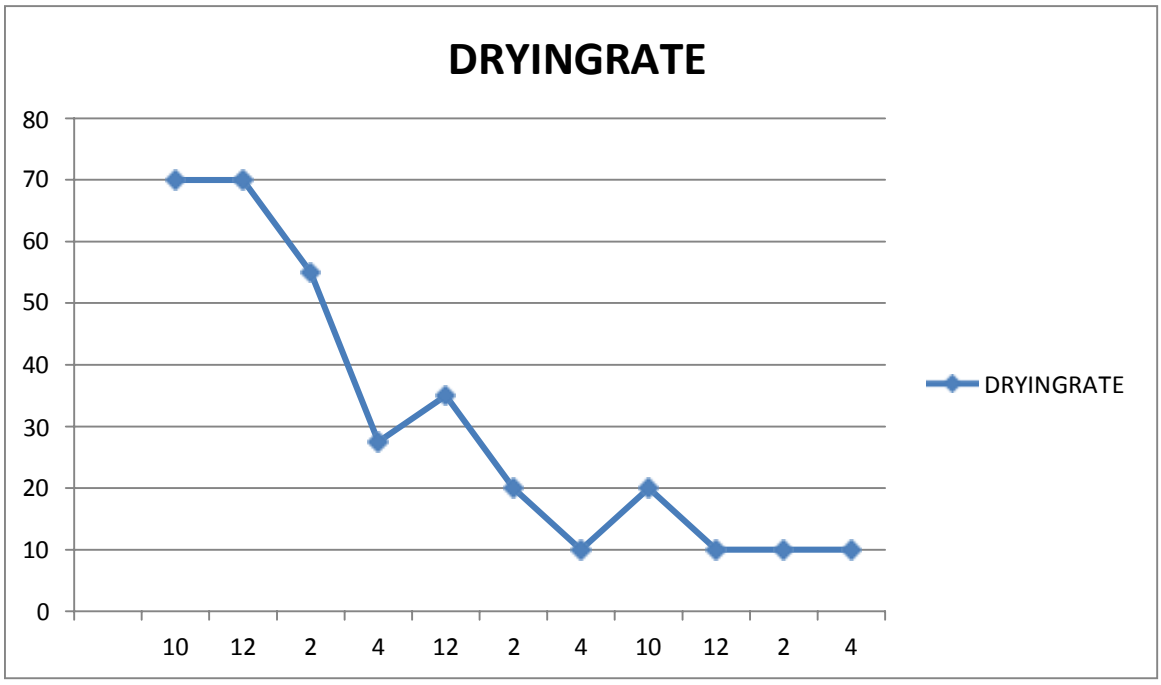

Fig.3DryingrateVSTime

IV. CONCLUSION

There are different types of solar dryers used to preserve foodfromwastageaswellasvalueaddition.Themaximumtemperatureobtainedis63^{o}C.Thedifferentsolardryingmethodsweremixedmodetype,forcedconvectiontype,indirectmodenaturalconvectiontype,cabinettypesolardryer, desiccant solar dryer, evacuated tube solar dryer, hybridsolar dryer, tray drier are more efficient than the open sundrying method. When compared with traditional drying thissolardryerprovidesmorequalityproductswithoutcontamination.

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